BIOLOGICAL EVALUATION OF GYPSY MOTH

at the

Beltsville Agricultural Research Center

2002

Prepared by

Rodney L. Whiteman
Forester
and
Bradley P. Onken
Entomologist

USDA Forest Service
Forest Health Protection
Morgantown, WV 26505

December 2002

ABSTRACT

In the Fall of 2002, USDA Forest Service personnel conducted a gypsy moth egg mass survey at the Beltsville Agricultural Research Center (BARC) to evaluate the efficacy of this year's suppression project and to assess the potential for defoliation and the need for treatment in 2003. Current populations are sufficient to cause noticeable defoliation on approximately 986 acres. Treatment is recommended to prevent defoliation and possible tree mortality.

METHODS

Gypsy moth survey plots were randomly selected based upon available host trees (oak species), size of sample area and uniformity between egg mass counts. At each sample point, a 1/40th acre fixed radius plot was established. The plots consisted of a tally of all new (2002) egg masses observed on overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre.

Egg mass length was measured at most of the plots to determine the overall "health" of the existing population and as a measure of egg mass fecundity. The average egg mass length (measured in millimeters) and egg mass density (egg masses per acre) were used to estimate defoliation potential (Liebhold et al., 1993).

RESULTS

The location of the survey plots are shown in Figure 1. The summarized results of the survey are presented in Table 1. Egg mass densities throughout BARC ranged from 0-11,720 and averaged 1,321 egg masses per acre. Most of the areas that are heavily infested by gypsy moths are located east of Rt. 295. Overall egg mass lengths tended to be large in size, ranged from 15-44 mm and averaged 28 mm.

The suppression project conducted during the Spring of 2002 provided fairly good results. No defoliation was detected in any of the seven treatment blocks (Figure 2) and the average egg mass density has been reduced 37 percent from the pre-treatment level of 1,575 to the current level (post-treatment) of 986 egg masses per acre. Only 42 out of the 411 acres or 10% of the area treated will need to be re-treated in 2003.

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include: previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food; and risk of larval blow-in following egg hatch. Potential defoliation is categorized as; light (1-30 percent); moderate (31-60 percent); and heavy (61-100 percent).

The survey results indicate that a noticeable defoliation (moderate and/or heavy) is likely to occur in eight areas encompassing 986 acres at BARC in 2003 (Figure 3). Four of the areas, totaling only 17 acres are small woodlots located west of MD Rt. 1. The fifth area is 31 acres and is dissected by Powder Mill Road and located to the east by MD Rt. 295. The three largest areas encompass 938 acres and are located to the west by MD Rt. 295 and to the north by Powder Mill Road.

Table 1. – Gypsy moth egg mass survey results at the Beltsville Agricultural Research Center, Fall 2002.

Plot Number		Number Em/Acre	Plot Number		Number Em/Acre
1	*	440	36		0
2	*	1,040	37		40
3		120	38		0
4		120	39	*	560
5		200	40	*	1,080
6	*	7,120	41	*	3,320
7	*	520	42	*	40
8	*	3,680	43	*	11,720
9	*	6,200	44	*	440
10		760	45	*	1,360
11		40	46	*	440
12		320	47	*	880
13		40	48	*	800
14		120	49	*	6760
15		0	50	*	4,000
16		40	51	*	240
17		880	52	*	400
18		0	53	*	2,720
19		760	54	*	760
20		120	55	*	240
21		80	56		80
22		560	57		320
23		120	58	*	7,200
24		120	59	*	5,640
25		2,160	60	*	80
26		160	61	*	2,680
27		40	62	*	280
28		160	63	*	760
29		0	64	*	280
30		240	65	*	520
31		440			
32	*	880			
33	*	1,800			
34	*	2,440			
35		600			

Overall egg mass/acre range = 0-11,720
Overall egg mass/acre average = 1,321

Egg mass size range (mm) = 15-44
Egg mass size average (mm) = 28

* = Located within proposed treatment blocks

Egg mass/acre range in proposed treatment blocks = 40-11,720
Egg mass/acre average in proposed treatment blocks = 2,210

This defoliation prediction is further supported by using egg density as a means of estimating gypsy moth population densities. Moore and Jones (1987) found that estimating the mean fecundity would increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. Using Liebhold's model, Figure 4 shows how this information can be used to correlate the predicted defoliation of an area. Accordingly, the estimated egg mass density of 3,167 egg masses per acre (average egg mass density in the four small woodlots west of MD Rt.1) x 28 mm (average egg mass length) translates to a projected defoliation level of about 69 percent (heavy defoliation). Because egg mass densities and host type are not evenly distributed, actual defoliation will vary from tree to tree but will be predominately heavy throughout these areas of BARC. Moderate defoliation (44, 50, and 39 percent, respectively) is projected in the block dissected by Powder Mill Road and in the two largest blocks east of MD Rt. 295. Heavy defoliation (79 percent) is projected for the smallest block east of MD Rt. 295. Elsewhere at BARC, defoliation is not expected to be of significance.

Based on existing egg mass densities and the general size of egg masses, gypsy moth populations appear to be building and healthy throughout most areas surveyed at BARC. The average egg mass length is 28 mm. Egg masses larger than 25 mm typically indicate healthy populations with no obvious sign of stress from either the gypsy moth nucleopolyhedrosis virus (NPV) or the *Entomophaga maimaiga* fungus, two of the primary natural control agents that often express themselves in declining or stressed populations. There was no evidence that either one of these entomopathogens had significant impacts at BARC in 2002. Although it is still possible that either the gypsy moth fungus or the NPV could cause a general collapse next year, it is not likely to occur prior to a significant defoliation event occurring in 2003.

Predicting the extent of tree mortality that would result after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. Trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light-moderate defoliation (< 60 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems. A severe drought was experienced in this portion of Maryland during the summer months in 2002. Gypsy moth defoliation has not been detected at BARC over the last several years.

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) and the Cuyahoga Valley National Park (2002) provide examples of potential tree mortality. On the Allegheny National Forest, untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28) percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63-78 percent of the species composition, a loss of 25 percent of the total oak sawtimber and 14 percent of the total oak poletimber occurred after one year of moderate to heavy defoliation. At Cuyahoga Valley National Park following one year of heavy defoliation, significant mortality occurred in approximately 25 percent of the defoliated areas. In the mortality areas, oak mortality ranged from 22-98 and averaged 54 percent. In these examples, droughty conditions likely contributed to the level of mortality.

Based on observations of the existing health of the forested areas at BARC and the factors mentioned above, significant tree mortality is expected should defoliation occur. This mortality will be intensified if drought conditions are experienced again at BARC in 2003.

Management Options

For 2003, two management options have been evaluated for managing gypsy moth populations at BARC. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage and prevent tree mortality; and 2) reduce gypsy moth population below the treatment threshold. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga.* In areas with defoliating levels of gypsy moth populations (greater than 750 egg masses per acre) viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels

Although it is not possible to accurately assess such events with information at hand, it is unlikely that a collapse will occur prior to defoliation since most of these areas are newly infested and there is an abundance of large healthy egg masses.

Large numbers of gypsy moth caterpillars and defoliation has been shown to impact competing native herbivore arthropods. Sample et al. (1996) showed short-term impacts of both species richness and abundance occurred following light to moderate defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that noticeable defoliation will occur in eight areas located at BARC in 2003.

Microbial Insecticide Option

***Btk*:** The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringienis* variety *kurstaki (Btk).* This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* is persistent on foliage for about 7-10 days.

Btk has been shown to impact other non-target caterpillars that are actively feeding at the time of treatment. An example of the potential impacts is provided by a study conducted by Miller (1990) in Oregon and Samples, et al. (1996) in West Virginia. Miller's study involved a large-scale (5,000 acres) eradication program where three consecutive applications of *Btk* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *Btk* were 50 acre plots and only a single treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were reduced but only for less than 1-year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

Btk formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *Btk* can be applied either undiluted or mixed with water for a total volume of ½-1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely.

Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it can be difficult at best to project

treatment efficacy without optimal conditions following treatment. Most often foliage protection is achieved but significant reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 2×10^{11} occlusion bodies (OB's) per acre applied in two applications, or a single application at 4×10^{11} OB's. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments. There are, however, sufficient quantities of Gypchek currently available for 2003 should this insecticide be preferred for use at BARC.

Alternatives

With the previously described options in mind, the following alternatives are offered.

Alternative 1	- No action
Alternative 2	- One aerial application of *Btk* at the rate of 36 BIUs in a total mix of ¾ gallon per acre.
Alternative 3	- Two aerial application of *Btk*, as in alternative 2, applied 4-7 days apart.
Alternative 4	- One aerial application of Gypchek at the rate of 4×10^{11} OB's in a total mix of 1 gallon per acre.
Alternative 5	- Two aerial applications of Gypchek at the rate of 2×10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.

RECOMMENDATIONS

As previously stated, gypsy moth populations are healthy, building and sufficient to cause noticeable defoliation on 986 acres at BARC in 2003 (Figure 3). To protect tree foliage and prevent subsequent tree mortality, our recommendation is Alternative 4 (a single application of Gypchek). This recommendation is based on the following conditions.

1. It is likely that BARC will be included in a suppression project that will involve other nearby federal sites (Greenbelt Park, NASA, Patuxent WRC, BW Parkway and Secret Service). The bulk of these lands are administered by the Department of the Interior and Gypchek is the preferred insecticide. Logistically is easier to use one insecticide. Therefore, Gypchek is the recommended insecticide.

2. A single application of Gypchek will likely provide adequate foliage protection and reduce the existing population below the treatment threshold in 50 percent of the treatment area.

3. The cost of a single application of Gypchek is about one half that of a double application of Gypchek.

4. Gypchek is host specific which minimizes the risk to other non-target organisms including lepidopteran caterpillars.

Only small and scattered areas of defoliation, if any, are expected elsewhere at BARC in 2003.

REFERENCES

Allegheny National Forest, Warren, PA. 1988. Gypsy moth caused oak mortality – Allegheny National Forest, 1988. USDA Forest Service internal report prepared by Forest Pest Management staff, Morgantown, WV. Unp.

Cuyahoga Valley National Park, Brecksville, OH. 2002. Oak Mortality Evaluation. Cuyahoga Valley National Park, 2001. USDA Forest Service Internal report prepared by Forest Health Protection staff, Morgantown, WV. Unp.

Gottschalk, K.W. 1990. Gypsy moth impacts on mast production, *In:* McGee, Charles E. Ed. Proceedings of the Workshop, southern Appalachian Mast Management; 1989 August 14-16; Knoxville TN; University of Tennessee; 42-50.

Liebhold, A.M., Simons, E.E., Sior, A., and Unger, J.D. 1993. Forecasting defoliation caused by the gypsy moth from field measurements. Environ. Entomol. 22(1): 26-32.

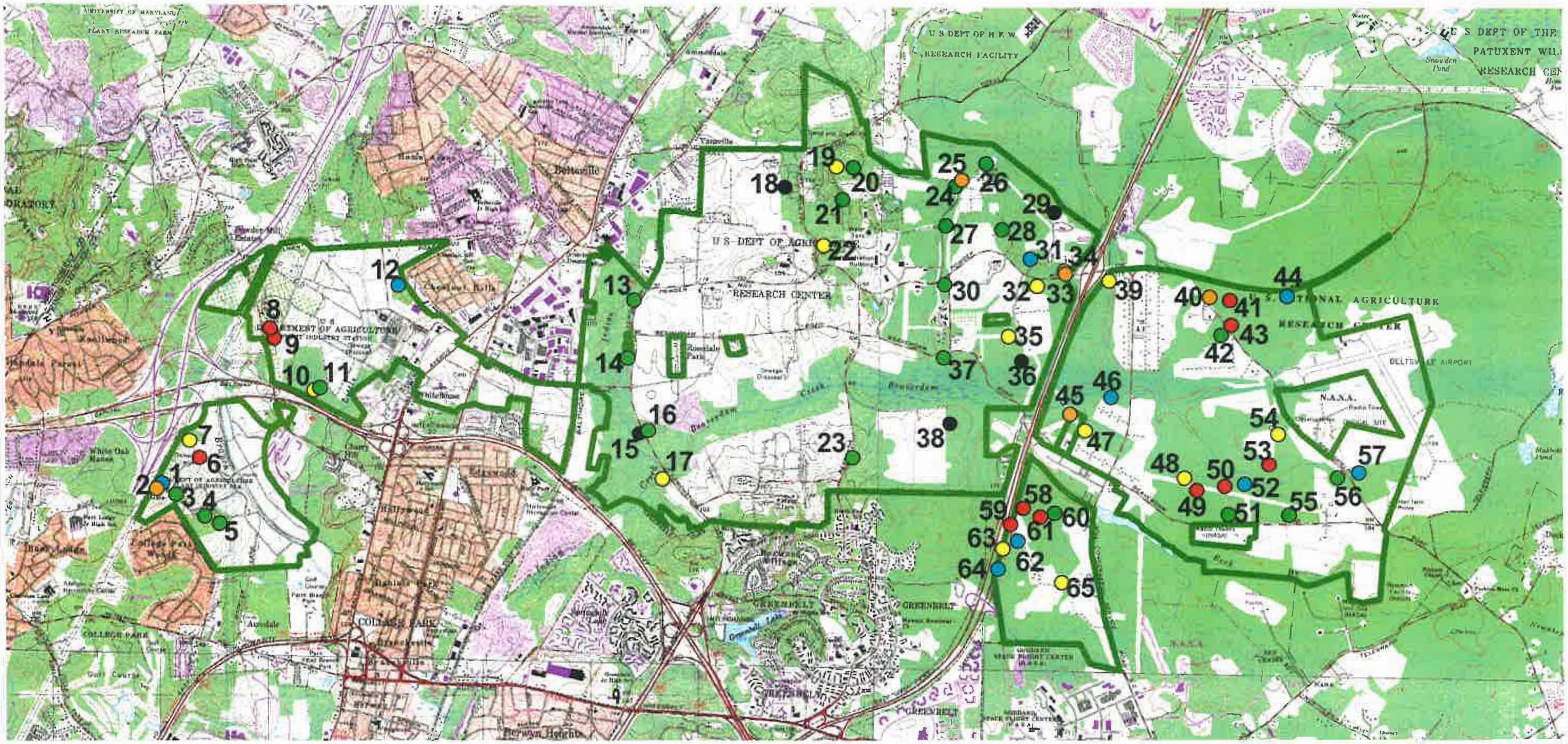
Miller, J.C. 1990. Field assessment of the effects of a microbial pest control agent on non-target Lepidoptera. American Entomologist 36:2, 135-139.

Moore, K.E.B. and Jones, C.G. 1987. Field estimation of fecundity of gypsy moth (Lepidoptera:Lymnatriidae). Environ. Entomol. 16: 165-167

Sample, B.E., Butler, L., Zivkovich, C., Whitmore, R.C., and Reardon, R.C. 1996. Effects of *Bacillus thuringiensis* Berliner var. *Kurstaki* and defoliation by gypsy moth [*Lymantria dispar* (L.) (Lepidoptera:Lymnatriidae)] on native arthropods in West Virginia. The Canadian Entomologist 128:573-592.

West Virginia Division of Forestry. 1997. *In* 1997 Cooperative State-County-Landowner Gypsy Moth Suppression Program in West Virginia. 3p. (Brochure).

Figure 1.-- Gypsy moth egg mass survey plot locations at Beltsville Agricultural Research Center, Fall 2002.



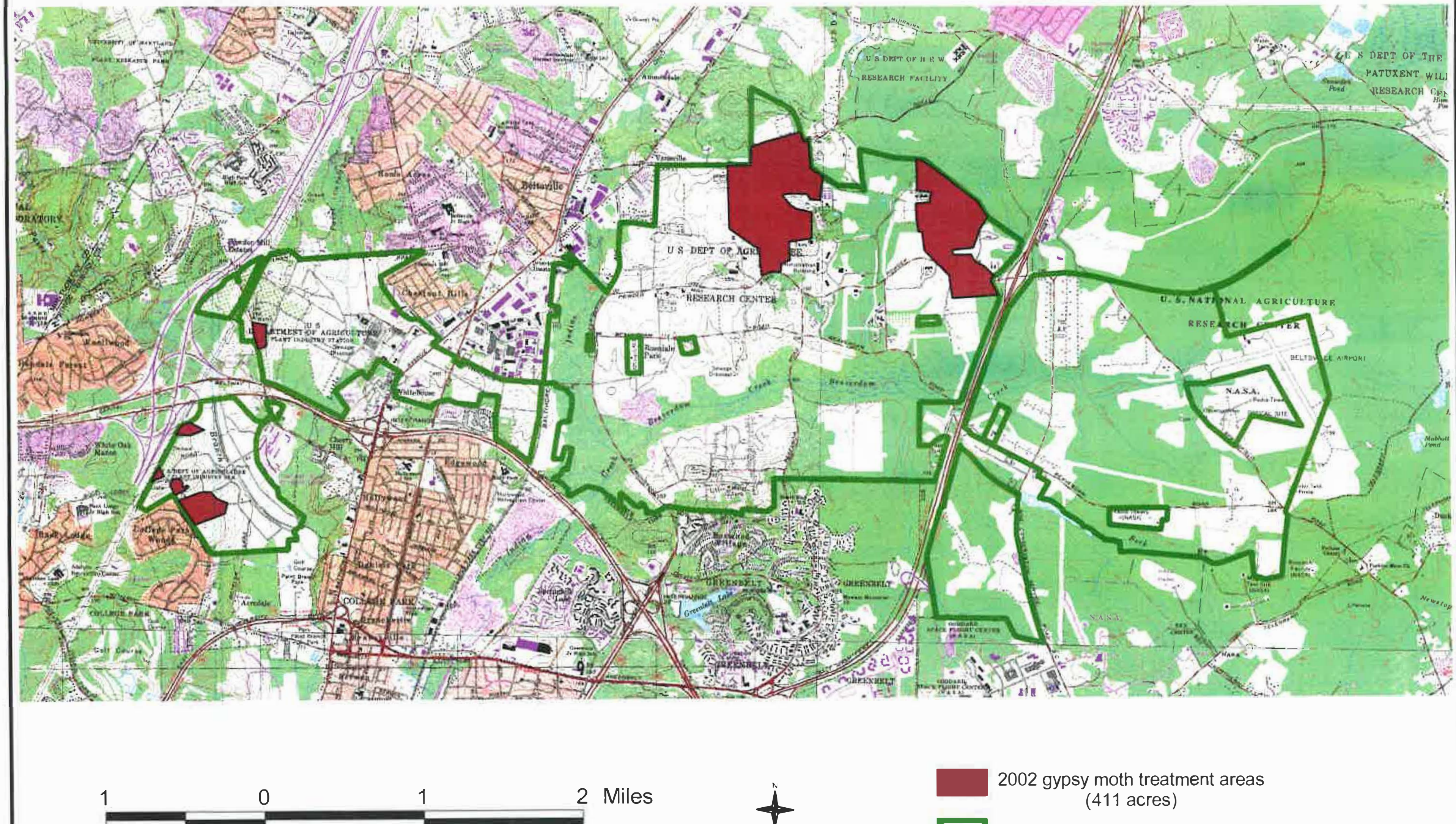
1 0 1 2 Miles

Plot locations
- 0 egg masses per acre
- 1 - 249 egg masses per acre
- 250 - 499 egg masses per acre
- 500 - 999 egg masses per acre
- 1000 - 2499 egg masses per acre
- 2500 - 11720 egg masses per acre
- BARC property boundary

USDA Forest Service, FHP, S&PF, Morgantown, WV

12/02 KDF

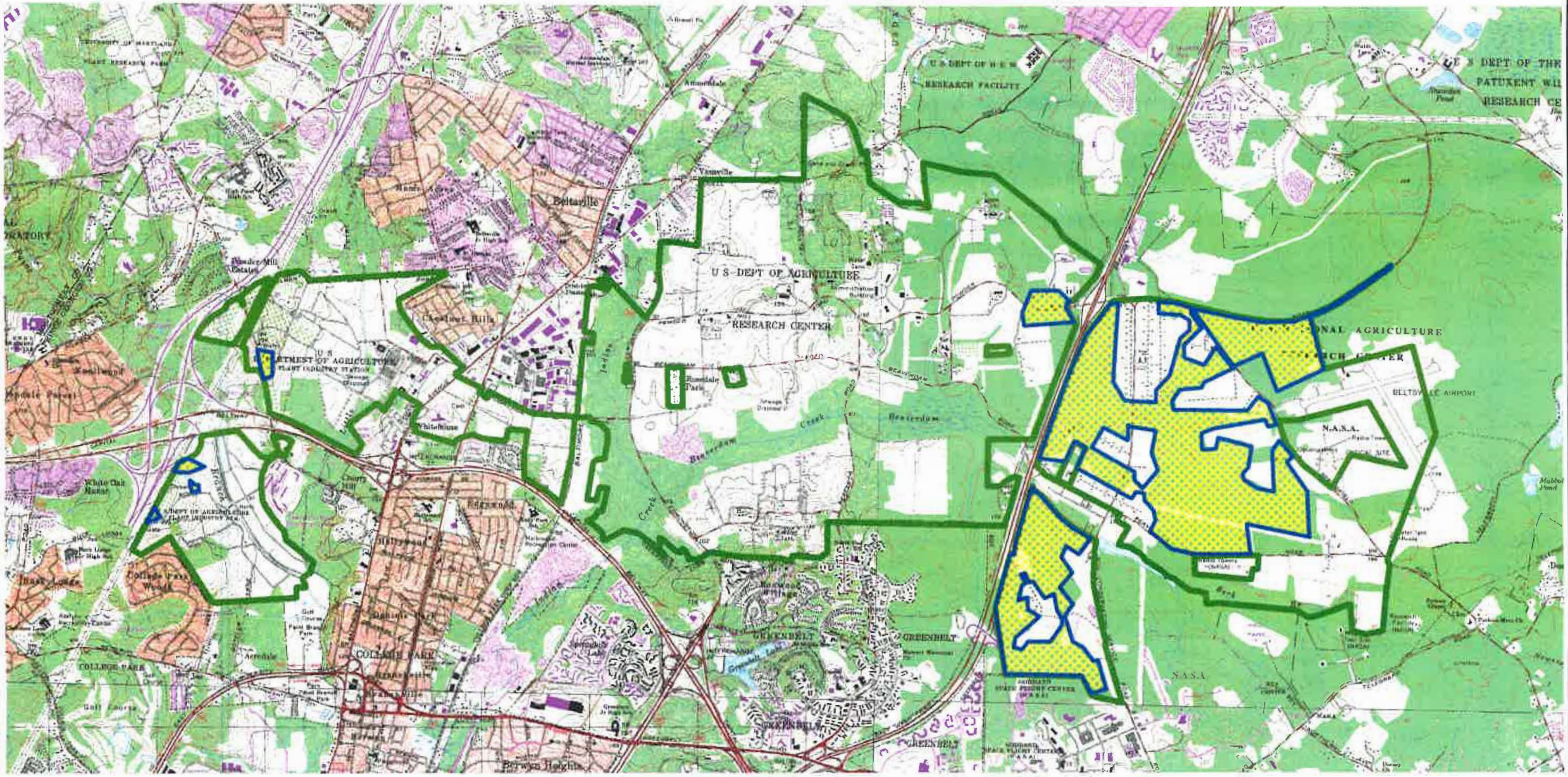
Figure 2.--Gypsy moth treatment blocks at Beltsville Agricultural Research Center in 2002.



USDA Forest Service, FHP, S&PF, Morgantown, wv

12/02 KDF

Figure 3.-- Areas where defoliation is likely/proposed treatment blocks at Beltsville Agricultural Research Center in 2003.



1 0 1 2 Miles

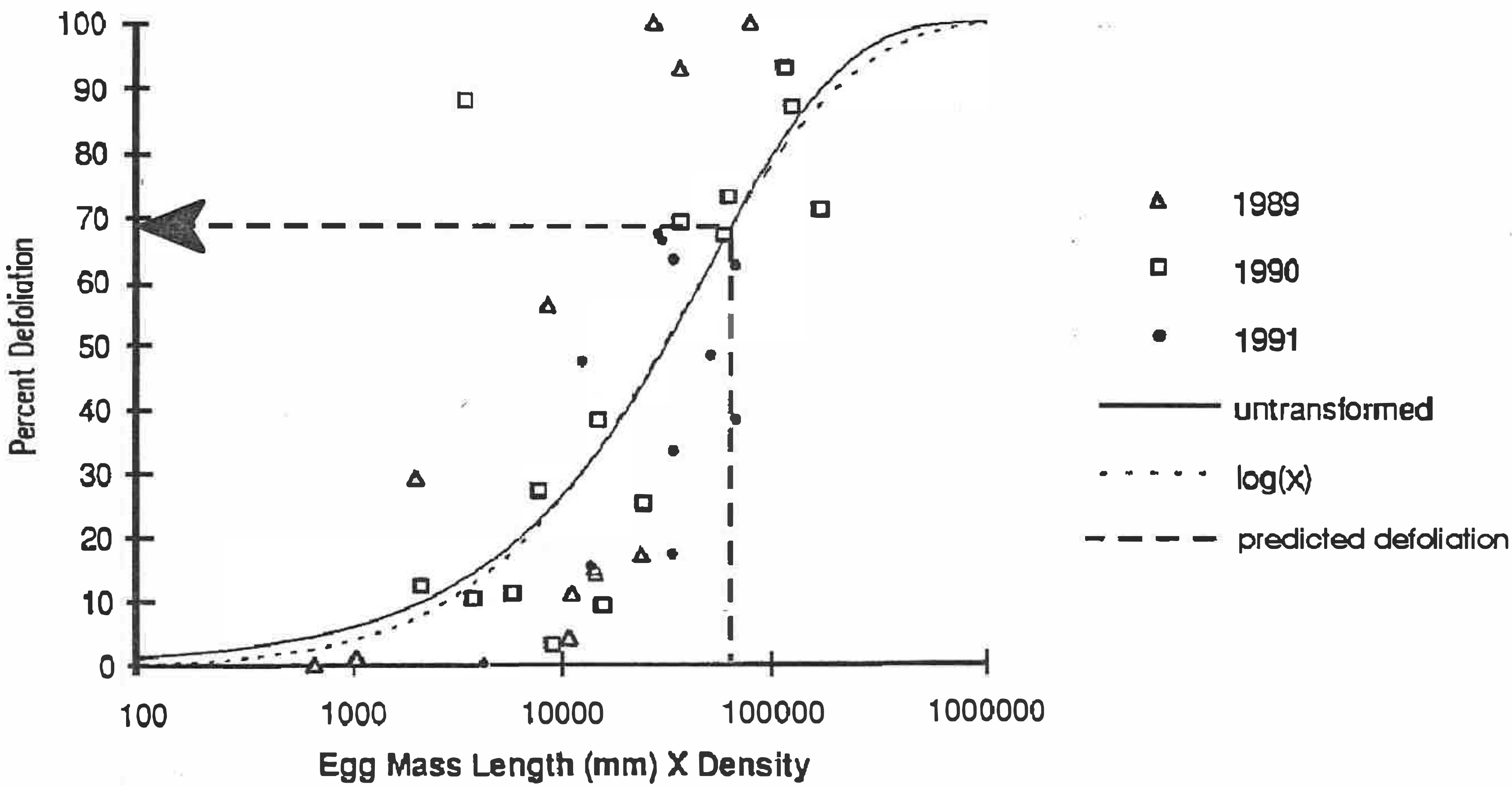
Areas where defoliation is likely/proposed treatment in 2003 - (986 acres)

BARC property boundary

USDA Forest Service, FHP, S&PF, Morgantown, WV

12/02 KDF

Figure 4.--Predicted defoliation in 4 small woodlots west of MD Rt. 1 at BARC in 2003



Scatter plot of the product of mean egg mass length and egg mass density versus mean defoliation. Extracted from Liebhold et al. (1993).

United States Department of Agriculture | Forest Service | Northeastern Area State & Private Forestry | 180 Canfield Street Morgantown, WV 26505-3101

File Code: 3410
Date: January 6, 2003

Mr. Kevin Thorpe
USDA Agricultural Research Service
Beltsville Agricultural Research Center-East
B-402, BARC-East
Beltsville, MD 20705

Dear Mr. Thorpe:

Enclosed is the gypsy moth biological evaluation for the Beltsville Agricultural Research Center.

In brief, gypsy moth populations are sufficient to cause noticeable defoliation on 986 acres at BARC in 2003. Most of the defoliation is likely to occur east of MD Rt. 295 We are recommending a single application of Gypchek at the rate of 4 X 10^{11}. With proper application, gypsy moth defoliation should be minimal at BARC in 2003.

Please contact Rod (304) 285-1555 or Brad (304) 285-1546 if you have any questions concerning the Gypsy Moth Biological Evaluation.

Sincerely,

JOHN W. HAZEL
Field Representative
Morgantown Field Office

Enclosure

Cc: Robert Tichenor, MDA
Sally Hughes, MDA
Bernie Raimo, DFO
Mike Connor, SPFO
Noel Schneeberger, AO

JWH/RLW/blm